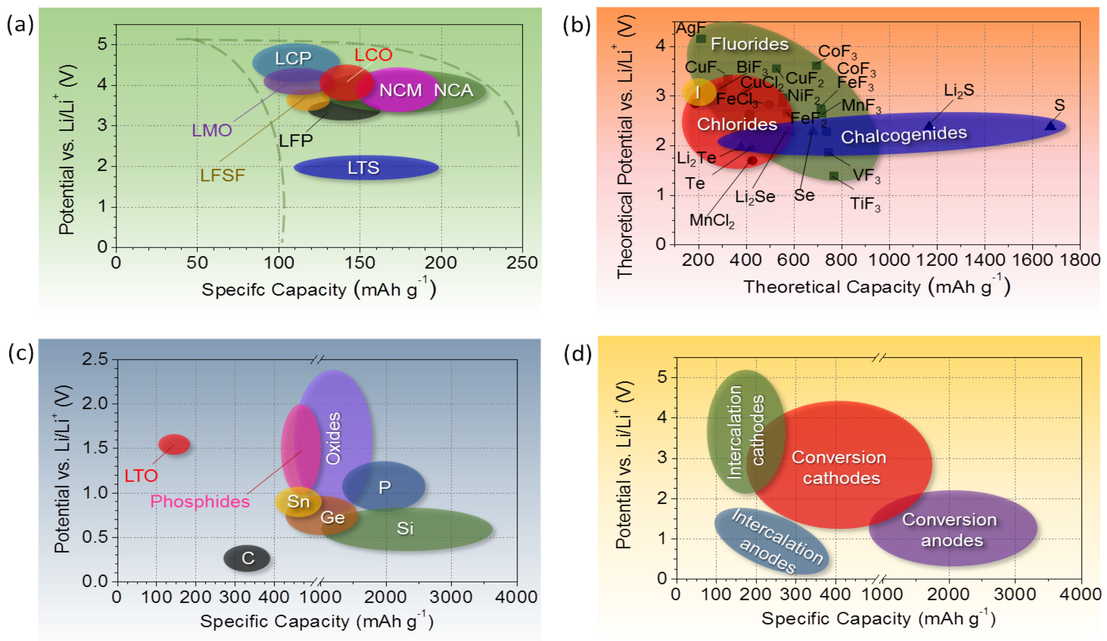
DOE VTP Incubator Project (PI: Alex Jacobs; Project ID: ES244)

Low Cost, High Capacity Non-Intercalation Chemistry Automotive Cells

Sila Nanotechnologies, Inc. (& Georgia Institute of Technology as a sub-contractor)

www.silanano.com

Intercalation vs. Non-intercalation Chemistries



Approach & Technology

- **High Energy Li-ion Cell: core-shell silicon-based anode vs. core-shell metal fluoride (MF_x) cathode**

✓ **No direct electrolyte-active material interactions:** Li ion permeable shell prevents unwanted side reactions

✓ **Conductive composite core**: transport of Li+ ions and electrons in both anode and cathode particles

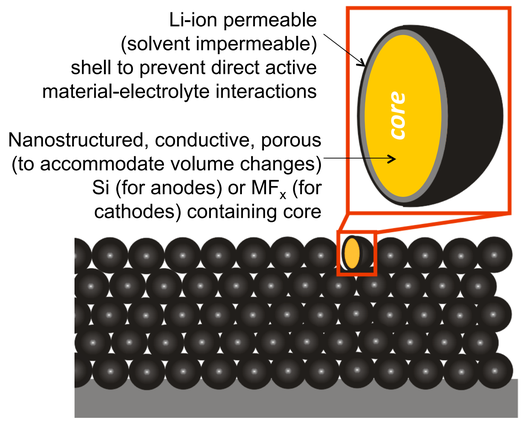
✓ **Minimal volume changes during cycling:** pores in the core provide space for volume changes during Li insertion/ extraction

✓ **Tunable properties**: precise control over particle size, conductivity and rate performance

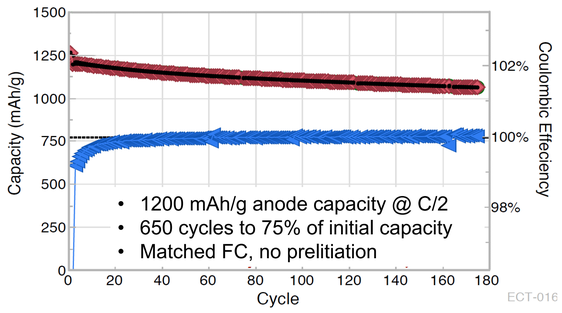
✓ **High volumetric capacities**: up to 1200 mAh/cc on the electrode level

✓ **"Drop-in" replacement:** micron-size nanocomposite powder is easy to cast using industry-standard tools

✓ **High capacity loading**: interstitials between individual spherical particles allow for the fast ion transport in thick electrodes because compaction of spheres does not block the ion pathways.



- **Anode stability in matched full cells:**



Timeline & Budget

✓ **Budget:**
- Gov't Share: $1,000,000
- Sila Share: $250,000

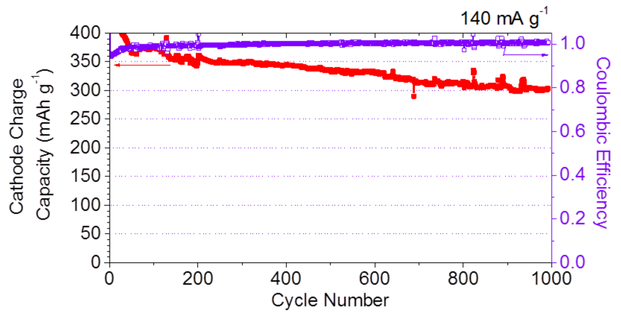
✓ **Timeline:**
- Start Date: October 1, 2014; End Date: September 31, 2016
- Percent Complete: 25%

Cell-Level Goals

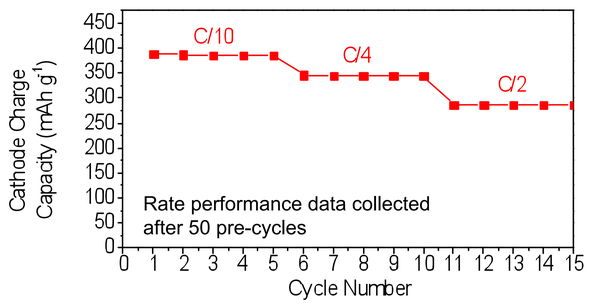
	U.S. DRIVE EV Cell-Level Goals	End of this Project Cell-Level Goals (2 years)	Follow-up Commercialization Effort Goals (4 years)
Discharge power density (W/l)	1500	**2400**	**5400**
Specific discharge power (W/kg)	700	**1160**	**2800**
Energy density @ C/3 discharge rate (Wh/l)	750	**1200**	**1300**
Specific energy @ C/3 discharge rate (Wh/kg)	350	**580**	**650**
Cycle life (cycles)	N/A	**200**	**2000**

Results & Discussion

GO / NO GO Milestone Description for Year 1	Meeting the Milestone	Results
Demonstrate Half Cells with 80% of the Theoretical Capacity	YES	**82% Theoretical Capacity Demonstrated**
Demonstrate Half Cells with 65% of the Theoretical Capacity on Cycle #1 with 65 Stable Cycles or more	YES	**1000 Stable Cycles (~30% degradation)**



- Promising initial experimental results on MF_x-Li half cells: stable performance (1000 cycles to 75% of initial capacity) and high coulombic efficiency (CE) approaching 100% on novel MF-based cathodes, suggesting their mechanical and chemical stability



- Good (for this chemistry) rate-performance at room temperature, suggesting the promise of our approach to overcome the commonly known challenges with MF_x chemistries – high electrical and high ionic resistance of fluorides

Collaborations with Other Institutions

✓ **Georgia Institute of Technology (sub-contractor):**
- Collaborator in powder synthesis
- Collaborator in material characterization and post-mortem analysis (TEM, EDS, XPS, SEM, etc.)
- Collaborator in electrolyte work

✓ **Army Research Laboratory:**
- Collaborator in Quantum Chemistry modeling

✓ **Automotive Partner:**
- Collaborator in cell design and testing regimes

Future Activities

✓ **Particle Synthesis:**
- Reduce the fraction of inactive (not MFx) components in the core-shell particles
- Utilize combination of different MFx for synergetic performance improvements (rate, stability, energy, etc.)

✓ **Cell-Related Work:**
- Further electrolyte optimization
- Introduction of Li into the full cells with Li-free anodes
- Full cell work with matching Si anode

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